

NASA Office of Aerospace Technology  
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# Aerospace Technology **INNOVATION**

## **NASA Helps Improve Weather Prediction**

**Cancer Screening Aid Approved  
Mapping Mission Yields Safer Flying  
Parachute "Lifeboat" Flies High**



# INNOVATION

Aerospace Technology

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#### About the Cover:

The view of Earth from space afforded by NASA's research satellites plays a vital role in improving weather prediction, and over the past 40 years has led scientists to see Earth as a complex and dynamic system.

**Online Edition:** Go to <http://nctn.hq.nasa.gov> on the World Wide Web for current and past issues.

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## COMMERCIAL DEVELOPMENT MISSION UPDATE

Date*	Flight	Payload	Sponsor/Coordinator
8/00	STS-106	Commercial Generic Bioprocessing Apparatus (CGBA)	Bioserve Space Technologies

\* As of June 2000.  
Key: STS—Space Transportation System

# WELCOME TO INNOVATION

## Earth Science in the New Decade

**By Dr. Ghassem R. Asrar**

*Associate Administrator for Earth Science  
NASA Headquarters*

**I**F WE COULD EXTEND PRACTICAL WEATHER forecasts to 7 to 10 days, the benefits to utility companies and to building contractors—to just about everyone—would be enormous. If we knew how much rainfall to expect next season, farmers could make better decisions about planting drought-resistant crops or more thirsty ones. If we understood the true shape of Earth's surface, and how the motions of Earth's interior affected it, we could begin to predict volcanic eruptions, earthquakes and floods. How will we get there? The same way the nation achieved the current three- to five-day forecasts—by linking NASA's satellite technology to the National Oceanic and Atmospheric Administration's operational weather forecasting capability, to the U.S. Department of Agriculture's agricultural extension programs and to the U.S. Geological Survey and Federal Emergency Management Agency's floodplain mapping, natural hazard preparedness and emergency warning products.

NASA's Earth Science Enterprise aims to obtain a scientific understanding of the entire Earth system on a global scale by describing how its component parts and their interactions function, and how they may be expected to change in both the near and distant futures. The challenge is to develop the capability to predict those changes that will occur in the next year, decade and century, both naturally and in response to human activity. The strategic objective of the Enterprise is to provide scientific answers to the overarching question: ***How is Earth changing, and what are the consequences for life on Earth?***

The view of Earth from space afforded by NASA's research satellites over the past 40 years has led scientists to see Earth as a complex and dynamic system. Its varied components of land, atmosphere, oceans, ice and life are highly interactive. Incoming energy from the Sun and the motions of Earth's interior drive these interactions. Especially in the last few millennia, and accelerating in recent centuries, human activities have constituted additional forces acting on the Earth system. These forces elicit a wide variety of responses in the Earth system. These include large-scale changes in

ecosystems over time (for example, when "ice ages" expand and recede, or when forested lands are converted to agricultural or residential use), or even frequent, severe storms. By examining Earth as a system, as the view from space enables us, NASA aims to understand the forces acting on Earth, their resulting responses and feedbacks and what their impacts are on agriculture, industry and other societal activities.

The Earth Science Enterprise is deploying the Earth Observing System (EOS), a constellation of satellites, to probe these key Earth system interactions. The first four EOS satellites were launched in 1999, and the remaining nine will be launched through 2003. Over the next few years, NASA is investing in building and launching more than 26 satellites to examine practically every aspect of our home planet from space. The Enterprise is also planning its research priorities and missions for the next decade. We are investing in advanced instrument technologies, including active sensors (radar and lidar) to resolve three-dimensional structures of the atmosphere and land surface, and improved passive sensors to extend long-term data records at reduced cost. We are investing in advanced computing and communications technologies to enable on-board information product generation and distribution and to create visualizations that allow for the understanding of massive quantities of data.

The next decade promises to be an exciting one. We will move beyond characterizing the Earth system to genuinely understanding how it works, so that we can begin to predict future change. New scientific knowledge and practical applications will be streaming from NASA's Earth-observing satellites. Advanced technology and lower cost missions will be developed to assure the continuity of essential scientific data and information while enabling new and innovative applications. Small, innovative missions will discover facets of the Earth system that we can only guess at today. An information management system will ensure affordable and timely delivery and access to data products by scientists, practitioners and policymakers. New ways of combining geospatial data into innovative, useful information products will engage a broader range of users to multiply the return on the national investment in Earth science. And the result will enable a robust climate, weather and natural hazard assessment and prediction capability, support for the efficient production of food and fiber, effective management of natural resources, and enhancement of the quality of life on Earth. ✱



# COVER STORY

## NASA Helps Improve Weather Prediction

**N**ASA'S ROLE IN STUDYING PLANET EARTH IS to further scientific research and technology to help forecasters make more accurate weather, climate and natural hazard predictions in the new millennium.

NASA technology and climate studies can help predict such dramatic events as El Niño and La Niña—providing advance notice that saved America billions of dollars last year alone. For the future, NASA has set goals for its Earth Sciences research and technology development projects that may result in new satellite technologies and models to help the National Weather Service replace the common three- to five-day forecasts of today with accurate 10- to 14-day forecasts.

With the use of satellite data and better computer modeling techniques, meteorologists in the next ten years may be able to predict El Niño weather conditions up to 15 months in advance and detect hurricanes far enough ahead to help protect lives and property, NASA Administrator Daniel Goldin recently told weather forecasters at the first annual American Meteorological Society (AMS) convention of the new millennium.

"What most people don't know is that our efforts to open the space frontier are largely based on our quest to understand our own planet," Goldin said in a keynote address to the AMS convention in Long Beach, California. "Our development of new technologies and Earth-observing spacecraft complement the vital work of our sister agencies in weather prediction and global climate modeling."

As one example, new research shows that adding rainfall data from NASA's Tropical Rainfall Measuring Mission (TRMM) satellite and other meteorological satellites to forecast models can more than

triple the accuracy of short-term rainfall forecasts. These findings were also presented to the AMS by researchers at Florida State University, Tallahassee, and will be featured in an upcoming edition of the *Journal of Climate*.

Spaceborne technologies used to study the effects of Hurricane Floyd indicate that extensive rainfall along the North Carolina coast may have significant impacts on the marine food chain and thousands of people.

"Following Hurricane Floyd, record-breaking rains continued to soak the area, washing mountains of sediment and waste into the water system,"

said NASA oceanographer Gene Feldman of NASA's Goddard Space Flight Center in Greenbelt, Maryland. Now rivers and tributaries along the Atlantic Ocean are choked and major ecological changes are happening.

"Periodically, levels of dissolved oxygen in the water have dropped dramatically as organic matter decomposes, and aquatic life has been threatened in dozens of

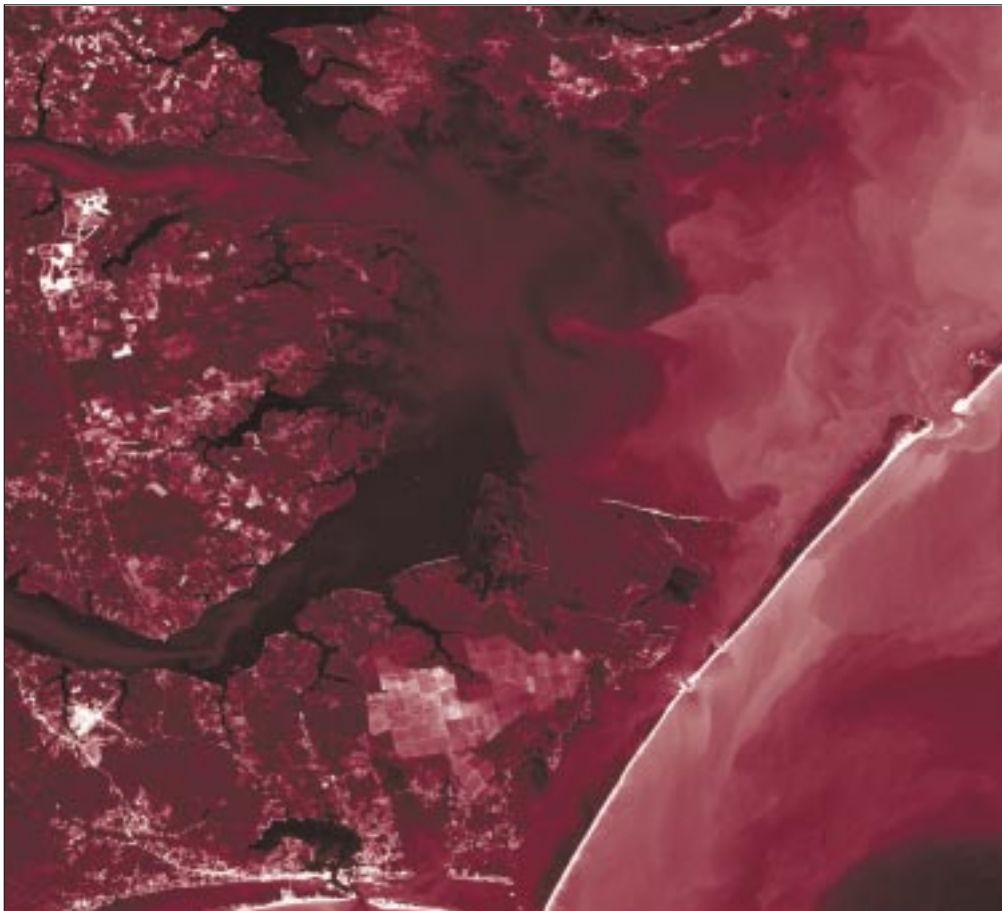
estuaries and peripheral habitats, commonly referred to as 'dead zones.' The current changes in the area may have lasting repercussions for hundreds of thousands of people," Feldman said.

The TRMM is a NASA/Japanese mission that continues to provide profound new insights into events such as hurricanes, probing them in three dimensions to reveal how energy is distributed within the storm. This knowledge will help experts understand how these most violent of Earthbound storms work. Experimental forecasts done last fall using this satellite's data demonstrated much better tracking of some of the year's devastating East Coast hurricanes, including Dennis and Floyd.

"Making such improvements in even the short-term forecasts is important because it demonstrates that we are learning more about the behavior of rainfall within these models," said Chris Kummerow, the spacecraft project scientist at Goddard Space Flight Center.

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—Daniel Goldin  
NASA Administrator



*Landsat 7 image of the Pamlico River in North Carolina after Hurricanes Floyd and Irene in September 1999. (Photo supplied by Goddard Space Flight Center's Science Visualization Studio)*

Scientists studying Hurricane Floyd's effect on algae blooms and phytoplankton, important links in the regional marine food chain, say their data will also help them understand how the hurricane's aftermath may affect the fragile environment in the coming months.

Using data from NASA's Earth-orbiting Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and an airborne laser instrument, scientists from the National Oceanic and Atmospheric Administration (NOAA) can monitor algae growth over large regions, including Pamlico Sound between the North Carolina mainland and the Outer Banks.

According to Pat Tester, a NOAA scientist at the Center for Coastal Fisheries and Habitat Research in

Beaufort, North Carolina, fertilizer and other nutrients that flowed down the storm-flooded rivers in eastern North Carolina are feeding the algae or phytoplankton in the sounds.

"One question is what happens to the aquatic activity in the sounds when this algae dies and begins to starve the waters of oxygen," Tester said. "The long-term observations provided by the NASA technology will help us monitor the phytoplankton in the water."

"The NASA technology improves our ability to monitor these important fishery areas by covering larger areas than direct sampling from boats can, and by providing this information for weeks or months," Tester said.

Additional ongoing Earth Science missions that contribute to our understanding of the global climate include:

- Landsat 7, an Earth-mapping satellite that provides imagery of the planet for use in understanding natural events all over the world. Building on a 27-year heritage of data, Landsat 7 can help researchers understand the effects of hurricanes and floods, as well as monitor large-scale fires and droughts all over our planet.
- QuikSCAT, a satellite launched last year that tracks wind currents over the ocean's surface. This information helps scientists understand the interactions between Earth's oceans and the atmosphere, and is being used by NOAA to improve marine weather forecasts.
- TOPEX/Poseidon, a NASA/French mission that uses radar to study ocean-surface topography and heat content, two more clues into how El Niño

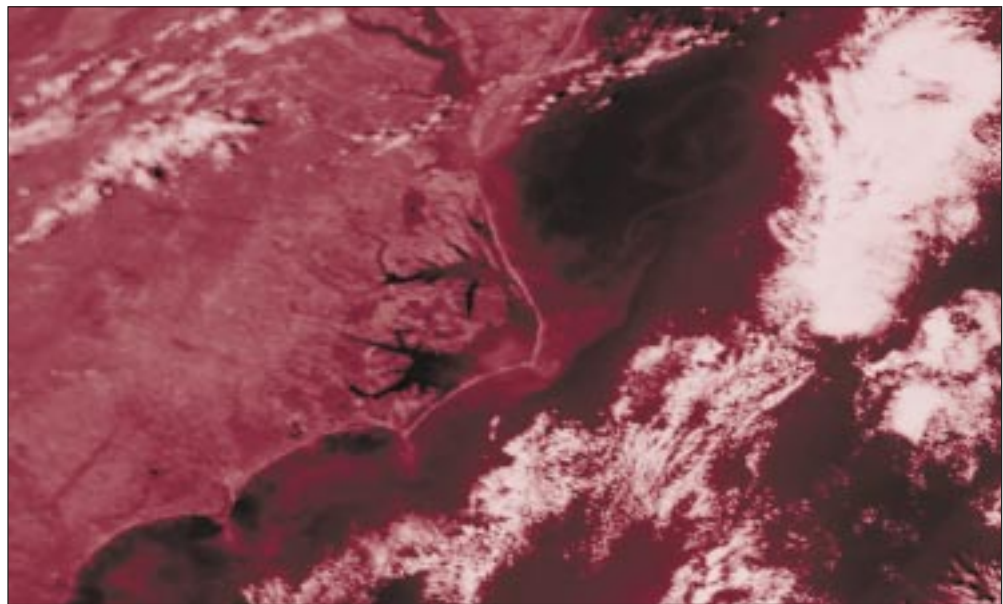
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BILLIONS OF DOLLARS LAST YEAR ALONE.

and other ocean events affect the weather that crosses our nation each day.

- The ACRIMSAT mission, launched last December, will measure how changes in the Sun's energy affect Earth's climate.
- Terra, also launched last December, will enable new research into the ways that Earth's lands, oceans, air, ice and life function as a planet-wide system. In the coming months and years, this major "Earth Observatory" will provide new insights into how our home planet behaves.

NASA's Earth Science Enterprise at NASA Headquarters in Washington, DC is a long-term research enterprise designed to study the Earth's land, oceans, air, ice and life as a total system. ✱

For more information, contact David E. Steitz at NASA Headquarters, ☎ 202/358-1730 or visit <http://www.earth.nasa.gov> Please mention you read about it in *Innovation*.



North Carolina flood, October 26, 1999. (Photo supplied by Goddard Space Flight Center's Science Visualization Studio)

# TECHNOLOGY TRANSFER

## NASA Technology Monitors Tiny Hearts

**A** NASA TECHNOLOGY ORIGINALLY USED TO measure airflow over airplane wings has been successfully used to develop a portable, noninvasive, easy-to-use fetal heart monitor. Researchers from NASA's Langley Research Center in Hampton, Virginia, worked with Veatronics, Inc., of Charlotte, North Carolina, to convert the technology to this innovative medical application. NASA granted the company a license to market one or more commercial products based on the technology.

"Because the material we used for wing surface measurements is flexible, it is ideally suited to fit over the curved surface of a maternal abdomen for fetal testing," said Allan Zuckerwar of Langley's Advanced Measurement and Diagnostics Branch.

The new, clinically proven fetal heart monitor takes advantage of aerospace technology to make it more affordable, portable and easy-to-use by expectant mothers in their own homes. It monitors, documents and stores fetal heart-rate data without injecting energy into the womb, making it totally noninvasive. Current fetal heart-monitoring devices generally work well, but they cost thousands of dollars and can only be used in a clinical setting.

Langley developed the portable technology at the suggestion of a medical doctor in a remote area that suffers from a lack of health care. For a number of reasons, expectant mothers who do not receive necessary prenatal care often suffer increased fetal mortality. In its present form, an at-home patient would strap a wide, soft belt embedded with sensors over her stomach, tune a computerized control device to hear the fetal heartbeat and send the signal directly to her doctor's office via the Internet.

A series of NASA-sponsored clinical trials were recently completed at the Morehouse School of Medicine in Atlanta, Georgia. Clinical trials were also sponsored at Eastern Virginia Medical School in Norfolk, Virginia, and at Encino/Tarzana Medical Center in Encino, California. The trials are expected to establish that the acoustic monitor meets federal Food and Drug Administration guidelines. The results are being compared to those recorded via

Doppler ultrasound and scalp-electrode monitors, as well as to standard accepted measurements.

The Morehouse trials show that the technology offers an easy-to-use alternative to visiting a doctor's office. This is especially important for high-risk patients who should be examined often, patients who cannot easily travel, those who cannot afford the time or money for periodic trips to the doctor or those who are required to undergo long periods of bed rest.

The new method of checking fetal heart behavior might actually prove to be a better way of monitoring some pregnancies than technologies now in use. In addition, the system could provide objective data to complement information gained from other methods. ✱

For more information, contact Sherry Sullivan at Langley Research Center.

☎ 757/864-2556, ✉ [s.l.sullivan@larc.nasa.gov](mailto:s.l.sullivan@larc.nasa.gov) Please mention you read about it in *Innovation*.

*A new, clinically proven fetal heart monitor takes advantage of aerospace technology converted by researchers from Langley Research Center and Veatronics, Inc., and makes it possible for expectant mothers to monitor their unborn baby's heartbeat at home. (Photo supplied by Langley Research Center)*





# Kennedy Space Center Technology Cleaning Up

**A** NASA-PATENTED SUPERSONIC CLEANING system technology, originally developed at NASA's Kennedy Space Center for the Space Shuttle program, has been licensed to three companies: CryCle Cryogenic Development NV, Preferred Engineering and Va-Tran Systems. The technology transfer to CryCle marks a historic landmark for Kennedy. CryCle is a Dutch firm, and the successful technology transfer marks the first time in Kennedy history that a U.S. patent owned by NASA has been licensed to a foreign company. The company has had partnerships with several American companies for other technological development and market support.

CryCle, a small high-tech business established in 1997, plans to develop and market the Gas/Liquid Supersonic Cleaning System, which was originally developed as a cleanliness verification tool to replace environmentally harmful solvents. Under terms of the patent license agreement, the company must substantially manufacture the system in the United States and is restricted to European marketing and sales. NASA inventors, as well as Kennedy Space Center, benefit from the collection of royalties that are negotiated as part of all patent license terms, according to Melanie Chan, Technology Programs manager, Licensing and Dual Use.

Preferred Engineering, a wholly owned subsidiary of Preferred Utilities Manufacturing Corporation of Danbury, Connecticut, has also received a license for the technology. Preferred Engineering, established in 1981, designs and manufactures special tooling for the nuclear utility industry. The supersonic cleaning system fits into the company's existing markets and provides an entry into such diversified markets as medical device manufacturing and semiconductor manufacturing.

According to the Preferred Engineering's Director of Projects, Richard Simoneau, "The supersonic cleaning system not only can be adapted to cleaning tools for our present nuclear market, but also can easily be adapted to other high-tech markets, such as pharmaceutical, semiconductor, medical and chemical industries. This gives us the ability to pro-

vide the system to our existing customers and capitalize off the experience to develop new but related uses."

Va-Tran Systems of Chula Vista, California, holds the U.S. patent rights and is marketing its own version of the cleaning system. Va-Tran found in further studies of the system that it is also excellent for the removal of adhesive, flux, fingerprints and heavy hydrocarbon contamination.

NASA Kennedy Space Center inventors developed the technology for cleanliness verification of complex Space Shuttle mechanical and electronic parts. The system is suitable for a variety of applications, from cleaning electronic circuit boards to scouring building exteriors. Although traditional high-pressure spray cleaning systems are often employed for cleaning various types of mechanical, electrical and fluid components, they unfortunately use very large quantities of solvents. The disposal of these solvents creates an environmental problem, especially with the use of Freon 113 or other chlorofluorocarbons (CFCs).

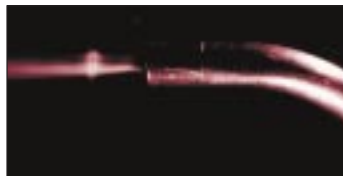
NASA's invention overcomes the deficiencies of prior systems. The cleaning spray system incorporates one or more converging-diverging nozzles to accelerate a gas-liquid mixture to a supersonic velocity for the cleaning of or contamination removal from various articles or components, and it uses less than 100 milliliters of water per minute. The liquid (typically water) can be collected and sampled to verify cleanliness. It can also be easily adapted to accept virtually any gas-liquid mix and flow rate combination. \*

For more information, contact Tom Gould, NASA Technology Programs & Commercialization Office, at Kennedy Space Center. ☎ 321/867-6238, ✉ Thomas.Gould-1@ksc.nasa.gov Please mention you read about it in *Innovation*.

# Cancer Screening Aid Approved

**A**N ADVANCED SENSOR DEVELOPED AT NASA'S Jet Propulsion Laboratory (JPL) recently received clearance from the Food and Drug Administration for a new breast cancer-fighting device. Called the BioScan System™, the device was developed by OmniCorder Technologies, Inc., Stony Brook, New York. OmniCorder received clearance to market the system in December 1999.

Studies have determined that cancer cells exude nitric oxide. This causes changes in blood flow in tis-



*The supersonic cleaning system, originally developed for the Space Shuttle program, has been licensed to three companies for a variety of applications. (Photo supplied by Kennedy Space Center)*



sue surrounding cancer that can be detected by the sensor. The BioScan System is sensitive to temperature changes of less than 0.027 degree Fahrenheit (0.015 degree Celsius) and has a speed of more than 200 frames per second. It causes no discomfort to the patient and uses no ionizing radiation.

"Clearance for use of this noninvasive diagnostic tool is an important milestone for us," said OmniCorder president and CEO Mark Fauci. He also noted that the device has also been cleared to be marketed for other applications.

Dr. Sarath Gunapala, principal engineer of JPL's device research and applications section, invented the sensor, which is called the Quantum Well Infrared Photodetector (QWIP). The digital sensor detects the infrared energy emitted from the body, thus "seeing" the minute differences associated with blood flow changes. Earlier versions of QWIP had such potential applications as locating hot spots during fires and observing volcanoes.

QWIP is currently being used with Mt. Palomar's 200-inch Hale telescope. It also will fly sometime in the next several months on a small space technology research vehicle mission to detect the severity of radiation in the Van Allen Belt. In addition, QWIP is being considered for use in the Astrobiology Institute's "search for life" mission.

The BioScan System also uses the Dynamic Area Telethermometer, invented by Dr. Michael Anbar, founding scientist of OmniCorder. The two technologies work together to image the target area and to provide the physician with immediate diagnostic information.

JPL is a division of the California Institute of Technology in Pasadena, California. ✱

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For more information, contact Dr. Sarath D. Gunapala at the Jet Propulsion Laboratory. ☎ 818/354-1880, ✉ [gunapala@mail1.jpl.nasa.gov](mailto:gunapala@mail1.jpl.nasa.gov) Please mention you read about it in *Innovation*.

## NASA ADDRESSES FUTURE AVIATION NEEDS

NASA's FutureFlight Central, recently opened at Ames Research Center, is a full-scale, research and development airport operations simulator that has the "look and feel" of an actual air traffic control tower cab. The mission of FutureFlight Central is to provide a world-class, research simulation facility to advance the safety, efficiency and cost-effectiveness of current and future airport designs, procedures and technologies. It supports cost-benefit studies, provides a stable platform from which new requirements can be derived, enables information sharing among multiple users and tests software performance, safety and reliability under realistic conditions.

With the introduction of new technologies and operating procedures, there will be increased efficiency, error reduction and overall system safety improvements, as well as an improvement in the flow of traffic on airport movement areas. FutureFlight Central will permit the integration of tomorrow's technologies in a risk-free simulation of any airport, airfield and tower cab environment. The facility provides an opportunity for airlines and airports to mitigate passenger delays by fine-tuning airport hub operations, gate management, ramp movement procedures and various other airport improvements. By providing a nonobtrusive operational test environment, FutureFlight Central will reduce the number of resources currently needed to conduct integrated system validation, and it will enable an efficient, well-planned, prevalidated transition of newly developed systems into the field.

FutureFlight Central provides a bridge among advanced research, functional testing, validation and deployment of new procedures, hardware, software and operational concepts for the air traffic control towers of the future. It enables air traffic controllers to provide input and become familiar with new airport operations and technologies before construction is completed.

NASA's FutureFlight Central is a world-class research facility, dedicated to addressing the future needs of the nation's airports," said Ames Center Director Henry McDonald. "This facility will allow NASA, the [Federal Aviation Administration] and their research partners to examine ways to increase the flow of aircraft through the national airspace system safely, efficiently and under all weather conditions."

"We can simulate any airport in the world," said Nancy Dorigi, FutureFlight Central facility manager. "The highly detailed three-dimensional model of an airport is viewed out the 360-degree windows of the tower cab. The visual scene, along with specific airport traffic patterns, fleet mix and procedures, makes this the ultimate test environment." ✱



*NASA's FutureFlight Central at Ames Research Center is capable of simulating any airport, airfield and air traffic control tower in the world. (Photo supplied by Boris Rabin, Ames Research Center)*

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For more information, contact John Bluck at Ames Research Center. ☎ 650/604-5026, ✉ [jbluck@mail.arc.nasa.gov](mailto:jbluck@mail.arc.nasa.gov) Please mention you read about it in *Innovation*.

# ADVANCED TECHNOLOGIES

## Monitoring Winds Improves Weather Prediction

**S**CIENTISTS, WEATHER FORECASTERS AND THE public now have access to a valuable stream of meteorological and climate measurements and observations that could improve weather forecasting around the world. The measurements and data products show developing weather systems with unprecedented detail. NASA and the National Oceanic and Atmospheric Administration (NOAA) are working together to transition these critical measurements from research to operational missions to improve the accuracy of current weather forecasts and to extend forecast projections from three to five days.

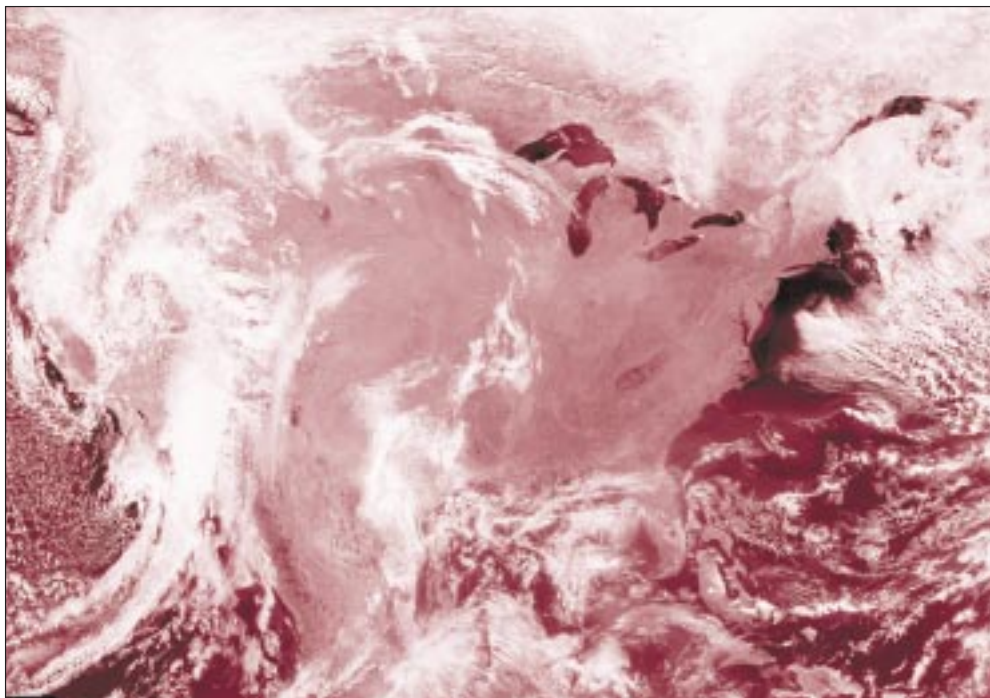
SeaWinds was launched on June 19, 1999, and engineers and scientists have successfully calibrated the satellite and verified the accuracy of its data over the past few months. These first calibrated measurements from NASA's SeaWinds instrument on the QuikSCAT satellite became available in early February. Daily wind data and animations from the ocean-wind tracker, managed by NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, are available

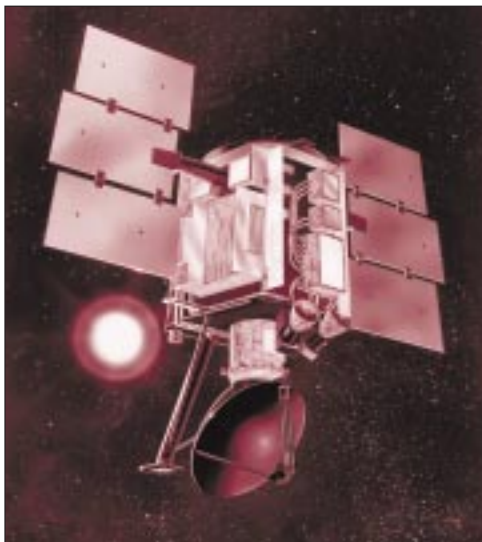
on the Internet at <http://podaac.jpl.nasa.gov/quikscat/>, <http://www-airsea.jpl.nasa.gov/seaflux> and <http://haifung.jpl.nasa.gov/>. JPL is a division of the California Institute of Technology in Pasadena.

The measurement of wind strengths at the ocean's surface, combined with satellite measurements of clouds, temperature and other data, can be used for understanding how different weather systems and storms develop, as well as for predicting weather over the entire globe. The measurements also are crucial for understanding ocean currents, climate patterns and the cyclical and anomalous variations that occur in those patterns to help in all human situations affected by weather, according to Dr. Michael Freilich, principal investigator on SeaWinds and a professor at Oregon State University in Corvallis.

The heart of SeaWinds is a specially designed spaceborne radar instrument called a scatterometer. The radar operates at a microwave frequency that penetrates clouds. This, coupled with the satellite's polar orbit, makes the wind systems over the entire world's oceans visible to SeaWinds on a daily basis. The measurements provide detailed information about ocean winds, waves, currents, polar ice features and other phenomena for the benefit of meteorologists, climatologists, oceanographers and mariners.

*The measurement of wind strengths at the ocean's surface, combined with satellite measurements of clouds, temperature and other data, can be used for predicting weather all over the Earth.*





Artist's rendering of NASA's Quick Scatterometer (QuikSCAT) satellite. The large, dish-like feature at the bottom of the satellite is the scatterometer instrument that will measure winds over ocean, land and ice in a continuous, 1,800-kilometer-wide band, making approximately 400,000 measurements per day.

"Near-real-time wind-vector measurements from SeaWinds represent a vast improvement in coverage over the generally data-sparse oceans," said SeaWinds science team member Dr. Paul Chang of NOAA's National Environmental Satellite Data and Information Service. "SeaWinds data will be used operationally by marine forecasters and for numerical weather prediction models. These data promise to yield significant improvements in short-term warnings and forecasts and in medium-to long-range forecasts."

JPL manages the orbiting SeaWinds radar instrument and is providing ground science-processing systems, as well as overseeing the development of the SeaWinds radar instrument. NASA's Goddard Space Flight Center in Greenbelt, Maryland managed the satellite's development; the satellite itself was designed and built by Ball Aerospace & Technologies Corporation in Boulder, Colorado. NOAA contributes ground system processing and distributes near-real-time SeaWinds data to the international operational weather forecasting community. ✱

For more information, contact Dr. Timothy Liu at the Jet Propulsion Laboratory.  
☎ 818/354-2394, ✉ [liu@pacific.jpl.nasa.gov](mailto:liu@pacific.jpl.nasa.gov) Or visit <http://www.earth.nasa.gov> Please mention you read about it in *Innovation*.

## Mapping Mission Yields Safer Flying

**T**HE RECENT SPACE SHUTTLE *ENDEAVOUR* mission (STS-99) is likely to help make flying safer through NASA's Aviation Safety Program (AvSP). AvSP is working with a number of industry teams to create and refine Synthetic Vision, a revolutionary cockpit display system that could give pilots a clear, electronic picture of what is ahead outside their windows, no matter what type of weather or the time of day.

NASA researchers envision a system that would use new and existing technologies to incorporate data into displays in aircraft cockpits. The displays would show terrain, ground obstacles, air traffic, landing and approach patterns, runway surfaces and other relevant data to the flight crew.

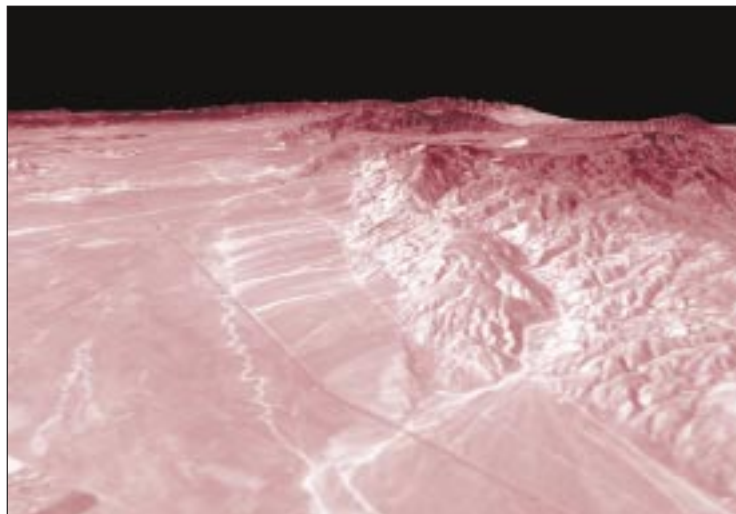
The mission of *Endeavour* was to produce the most accurate and complete topographic map of Earth's surface ever assembled. AvSP, headquartered at NASA's Langley Research Center in Hampton, Virginia, will use this terrain information, which could also be used to help develop Synthetic Vision for pilots and make flying commercial and private aircraft safer.

The Shuttle Radar Topography Mission (SRTM), designed to collect three-dimensional measurements of nearly 80 percent of Earth's land surface with an accuracy of better than 53 feet, is an international project sponsored by the National Imagery and Mapping Agency, NASA, the German Aerospace Center and the Italian Space Agency. Scientists will then use the three-dimensional images to generate computer versions of topographic maps, called digital elevation models, which can be used for a large number of scientific, civilian and military applications.

SRTM builds up Spaceborne Imaging Radar-C (SIR-C) technology that flew twice on *Endeavour* in 1994. To collect the topographic images, engineers added an almost 200-foot-long mast, additional C-band imaging antennas and improved tracking and navigation devices. The mast, the longest rigid structure ever flown in space, extended sideways from the orbiter's cargo bay. The antennas at the tip allowed the system to acquire stereo-like radar images of Earth's surface through a technique called interferometry.

Limited visibility is the greatest contributing factor to the world's deadliest aviation accidents, accord-





*Scientists will use three-dimensional measurements collected by the Shuttle Radar Topography Mission to generate digital elevation models, similar to this one.*

ing to Michael Lewis, AvSP director. NASA tested a prototype of Synthetic Vision in flights over Asheville, North Carolina, last year. Engineers loaded an experimental terrain database that had been augmented by sophisticated computer-rendering techniques onto a “flying simulator” research aircraft owned by the U.S. Air Force. During tests, pilots assessed how those three-dimensional images of the area compared with what was really outside the window.

It is expected to take about 18 months to process the terrain data from the Shuttle mission. AvSP officials hope a Synthetic Vision system can be available commercially in five years.

NASA's AvSP is a partnership with the Federal Aviation Administration (FAA), the Department of Defense, aircraft manufacturers and airlines. This partnership supports the national goal announced by President Clinton to reduce the fatal aircraft accident rate by 80 percent in 10 years and by 90 percent over two and a half decades.

In addition to Langley, three other NASA field installations are working with the FAA and industry to develop affordable technologies to make flying safer: Ames Research Center at Moffett Field, California; Dryden Flight Research Center in Edwards, California; and Glenn Research Center in Cleveland, Ohio. ✱

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For more information, contact Sherry Sullivan at Langley Research Center.  
 ☎ 757/864-2556, ✉ [s.l.sullivan@larc.nasa.gov](mailto:s.l.sullivan@larc.nasa.gov) For more information on NASA's AvSP, check the Internet at <http://avsp.larc.nasa.gov> For more information on SRTM, visit, <http://www.jpl.nasa.gov/srtm> Please mention you read about it in *Innovation*.

## Remote-Sensing Technology Proposals Selected

**N**ASA'S OFFICE OF EARTH SCIENCE AT NASA Headquarters in Washington, DC has selected proposals for a new technology development program that will support the Earth Science Enterprise by monitoring and predicting natural hazards to help minimize the loss of human life and mitigate property damage. The Advanced Technology Initiatives Program (ATIP) will provide for core component and subsystem technology developments that support NASA's science research of Earth-observing instruments in the area of spaceborne and airborne remote-sensing measurements.

The Office of Earth Science is awarding 23 proposals through NASA's Goddard Space Flight Center in Greenbelt, Maryland. In addition, nine proposals have been tentatively accepted. Contract awards for tentatively selected proposals depend on funding availability. The minimum period of performance is 12 months. The total proposed period of performance should not exceed 36 months.

“The selection of these proposals represent our commitment to the development of new, cutting-edge technologies that will help us to understand our complex global environment and provide this knowledge to future generations for informed decision making,” said Dr. Ghassem Asrar, associate administrator for Earth Science at NASA Headquarters.

ATIP is designed to bring instrument, platform and information system components and subsystems to a demonstrated technology readiness level, allowing for future integration into ongoing technology development programs, such as the Earth Science Enterprise Instrument Incubator Program, New Millennium projects and future Earth science missions. This is consistent with and supportive of NASA's new way of doing business by developing key and critical technologies the Agency needs to reduce the development cycle of missions, from five to seven years down to two to three years.

The goal of ATIP is to develop and demonstrate component and subsystem technologies that reduce the risk, cost, size and development time of three areas of importance to the Earth Science Enterprise: Earth-observing instruments, platforms and information systems. Another goal is to enable new Earth observation measurements.

The Office of Earth Science intends to implement the Earth science technology program with affordable access to space, leading to greater program flexibility. A major part of this enabling process is the rapid development of small, low-cost remote-sensing instruments. Technological innovations in reducing the size, mass and/or power requirements for the current instruments and for the development of future remote-sensing instruments are essential to the future success of the Earth Science Enterprise.

ATIP is part of that program. NASA's Office of Earth Science studies how our global environment is changing using the unique perspective available from space and airborne platforms; it is dedicated to studying the long-term effects of natural and human-induced changes on our global environment. NASA is observing,

documenting and assessing large-scale environmental processes, with current emphasis on seasonal-to-inter-annual climate variability, land-cover and land-use changes and global productivity, long-term climate change, atmospheric ozone research and studies related to the monitoring and prediction of natural hazards, minimizing the loss of human life and mitigating property damage. Satellite data, complemented by aircraft and ground data, are enabling researchers to understand environmental changes, to determine how human activities may have contributed to these changes and to understand the consequences of such changes. ✨

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For more information, contact Nand Topiwala at Goddard Space Flight Center.

☎ 301/286-7366, ✉ [topiwala@pop500.gsfc.nasa.gov](mailto:topiwala@pop500.gsfc.nasa.gov) Please mention you read about it in *Innovation*.

## GLOBAL WARMING PHENOMENON UNDER STUDY

A researcher from NASA's Marshall Space Flight Center in Huntsville, Alabama, working with a team of American and British investigators at the behest of the U.S. National Research Council (NRC), hopes a new joint study will shed additional light on the global warming phenomenon. According to the report, "Reconciling Observations of Global Temperature Change," the reality of global warming is not disputed. Just how much global warming Earth has experienced is the point of contention among many researchers, says Roy Spencer, senior NASA scientist for climate studies at the Global Hydrology and Climate Center in Huntsville. Estimates range from negligible change to a rise of 0.4 or 0.5 degree Celsius over the last 20 years.

The report, issued earlier this year at the annual conference of the American Meteorological Society in Long Beach, California, was produced to help resolve debate caused by differences between satellite measurements, which in the last 20 years have shown very little cumulative atmospheric warming, and surface-based measurements, which have shown substantial warming during the same period.

Researchers' first concern is the accuracy of their measurements, and not the origin of global warming. They are not trying to refute existing studies, nor are they pointing to a definitive cause for the trend. Rather, it is their hope to provide a more comprehensive overview of the global situation, using the latest in space technology to augment ground-based measurements.

The evidence reviewed by the NRC panel led them to conclude that recorded differences between surface and upper air trends over the past two decades are "at least partially real," according to the report. While the report does not attribute the surface warming to a particular cause, it does address possible reasons why the upper air may have warmed less rapidly than the surface. These reasons include both natural factors and human activities. The report also cites the susceptibility of surface- and satellite-based instruments and measuring techniques to some degree of error, leading to the disparate findings.

"The final consensus of the NRC study team is that satellite measurements do not refute the fact that surface temperatures have been rising," Spencer says. The study concludes that further research is needed to fully explain the differences between surface and tropospheric global warming trends.

"High-quality measurements are key to understanding this phenomenon," Spencer says. "It could take many more years of satellite-based and ground-based measurements before we can say just how much warming is the result of human activity as opposed to natural climate fluctuations."

The Global Hydrology and Climate Center is a joint venture between the government and academia to study the global water cycle and its effect on Earth's climate. Funded by NASA and jointly operated by Marshall and the University of Alabama in Huntsville, the center conducts research in a number of critical areas. Satellite tracking of hurricanes promises to improve global, severe weather forecasting capabilities. Research into lightning activity is providing new insight on the formation of tornadoes. Thermal studies of metropolitan areas are helping alert citizens and urban planners to the detrimental effects of the urban heat island. Also, NASA remote-sensing technologies explore new ways to aid farm productivity and identify outbreaks of disease. ✨

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For more information, contact Steve Roy at Marshall Space Flight Center. ☎ 256/544-0034, ✉ [steve.roy@msfc.nasa.gov](mailto:steve.roy@msfc.nasa.gov) Or visit <http://www.msfc.nasa.gov/news> Please mention you read about it in *Innovation*.

# AEROSPACE TECHNOLOGY DEVELOPMENT

## Parachute “Lifeboat” Flies High

**N**ASA’S X-38 PROTOTYPE CREW RETURN vehicle successfully completed its fifth atmospheric test flight at NASA’s Dryden Flight Research Center in Edwards, California.

“By intercepting the space flight return profile, we verified the X-38’s operation in a phase of flight it will encounter as a station lifeboat,” said John Muratore, X-38 Crew Return Vehicle Program Manager. “As our tests continue over the next couple of years, they will replicate those conditions more and more, culminating in a complete return from orbit.”

In the highest, fastest and longest test of the X-38 to date, the vehicle was released from Dryden’s NB-52 airplane at an altitude of 39,000 feet and flew free for 44 seconds, reaching a speed of more than 500 miles per hour before it began to deploy its parachutes. Opening at the same speed and altitude as it will during a return from space, a 60-foot-diameter drogue parachute pulled behind the craft first slowed the X-38 to about 70 miles per hour.

Then, a 5,500-square-foot parafoil, about as wide as the wings of a Boeing 747, began a phased opening, successfully demonstrating a new, more stable parafoil design recently developed by the X-38 team. The revised parafoil proved successful in ensuring a smooth ride for the craft during its 11.5-minute descent. The X-38 touched

down smoothly on target, even though one of three landing skids did not deploy.

The test was also the first use of automatic flight control software aboard the X-38. The new software, developed in a fraction of the time and cost of past spacecraft software, performed flawlessly.

The X-38 is a prototype “lifeboat” for the International Space Station, designed to carry up to seven passengers home from orbit in an emergency. The project combines proven technologies—a shape borrowed in part from a 1970s Air Force project—with some of the most cutting-edge aerospace technology available today, such as the most powerful electric motors ever used to control a spacecraft.



*The X-38 technology demonstrator descends under its steerable parafoil toward a lakebed landing in a March 2000 test flight. (Photo supplied by Tom Tschida)*



This innovative approach is enabling the X-38 to be developed at a tenth of the cost of past estimates for such a project. Although the United States leads the development of the X-38, international space agencies also are participating. Contributing nations include Germany, Belgium, Italy, the Netherlands, France, Spain, Sweden and Switzerland.

Throughout the rest of this year and 2001, increasingly complex, unpiloted X-38 atmospheric flight tests will continue at Dryden. A space test of an unpiloted X-38 is planned for 2002, when a vehicle already under construction at NASA's Johnson Space Center in Houston, Texas will be released from a Space Shuttle to fly back to Earth. ✱

THE X-38 IS A  
PROTOTYPE "LIFEBOAT" FOR THE  
INTERNATIONAL SPACE STATION,  
DESIGNED TO CARRY UP TO  
SEVEN PASSENGERS HOME  
FROM ORBIT IN AN EMERGENCY.

works. The technology also has the potential for enhancing the function of flight data recorders, known as black boxes, with Data Turbine-enabled communications networks. The software would maintain a history of on-board and ground-based information flow with participating users, allowing

immediate access to information that may or may not be recoverable from a flight data recorder following an aircraft crash.

"The Data Turbine is a piece of the aviation safety puzzle," says Larry Freudinger, Dryden's lead engineer on collaborative computing environments. Freudinger developed the Data Turbine software. Dryden is expanding Data Turbine uses with development partner Creare,

Inc., of Hanover, New Hampshire.

Advantages of this technology include a network-oriented infrastructure for managing information on an aircraft. Continuous updates of weather information to and from an aircraft can be integrated with engine health monitoring and other tools, which may automatically signal appropriate people when something indicates a potential safety hazard. The Data Turbine software is a network data server that is inserted between data sources and its users. It is analogous to a neuron, which has a mechanism to receive, store, process and forward signals from many sources to many destinations. A network of Data Turbine servers creates a type of digital nervous system that bonds applications and data sources together.

The software allows connected users to extract or input audio and video information instantaneously, no matter what type of computer they are using. It is efficient and cheap and allows different software packages to work collaboratively. The Data Turbine software can also separate information as well as integrate it. For example, a data stream could include information about sports, concerts and news. If someone wanted only news, he or she could get just the news using the software as well as receiving all three if desired. For researchers, this means that they can use one set of computer codes to collect information, another

For more information, contact Bob Baron at Dryden Flight Research Center.  
☎ 661/276-3172, ✉ [bob.baron@dfrc.nasa.gov](mailto:bob.baron@dfrc.nasa.gov) Please mention you read about it in *Innovation*.

## Software Promises Enhanced Flight Safety

**N**EW SOFTWARE DEVELOPED AT NASA'S DRYDEN Flight Research Center in Edwards, California shows promise for making air travel safer. It provides pilots, air traffic management, maintenance personnel and others constantly updated information about an aircraft and its surroundings.

The software, called the Ring Buffered Network Bus, is now a fledgling commercial product called the Data Turbine™. It offers a solution for how to meet the often-conflicting goals of providing high-performance data acquisition and quick access to those data by many users. The Data Turbine has become one of the enabling technologies now being developed for NASA's Aviation Safety Program.

Using this technology, entire fleets of aircraft may soon be able to communicate with each other and with ground-based facilities through computer net-

to analyze it and a third to report the results and use them collaboratively in an integrated way using a Data Turbine.

To demonstrate the utility of this technology, six Data Turbine servers will be used on NASA's DC-8 Airborne Science Flying Laboratory, in flight-test mission control centers and at remote sites to assist with flight research. A year from now, the DC-8's airborne network will be connected to the terrestrial network via a satellite in geosynchronous orbit. The intercenter project team plans to place weather sensing, vehicle health monitoring and network protocol experiments on that network in the context of evolving a reliable software infrastructure for information sharing on a global scale, Freudinger said.

A grant from NASA's Ames Research Center, Moffett Field, California, has focused on information technology research and the data-sharing needs of future air transportation systems. ✱

For more information, contact Larry Freudinger at Dryden Flight Research Center. ☎ 661/276-3142, ✉ [larry.freudinger@dfrc.nasa.gov](mailto:larry.freudinger@dfrc.nasa.gov) Please mention you read about it in *Innovation*.

## Aircraft Validates X-33 Range System

**E**NGINEERS AT NASA'S DRYDEN FLIGHT Research Center and the Air Force Flight Test Center, both from Edwards, California, using NASA's high-altitude ER-2 airplane equipped with X-33 avionics, have completed operational tests of a diverse network of range facilities and ground stations that make up the X-33 extended test range.

The unpiloted X-33 is a half-scale technology demonstrator of a full-scale, commercially developed reusable launch vehicle, which Lockheed Martin Skunk Works has named VentureStar™, planned for development within the decade. The X-33 will take off vertically

like a rocket, reaching an altitude of up to 60 miles and speeds faster than Mach 13, and will land horizontally like an airplane. Although suborbital, the X-33 will fly high enough and fast enough to encounter conditions similar to those experienced on an orbital flight path to fully prove its systems and performance.

The test flights took place over three states (California, Nevada and Utah) and included three Air Force ranges. The objective of the range test was to validate Dryden's portion of the X-33 range systems. Dryden's Airborne Science ER-2 aircraft, with X-33 flight communications equipment aboard, flew the flight path designated for the X-33 to the Army's Dugway Proving Ground in Utah. The X-33 communications equip-

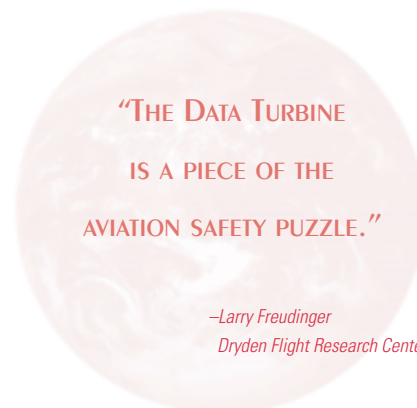
ment flown on the ER-2 was thoroughly flight qualified.

The ER-2, flying at 65,000 to 70,000 feet, completed two flight paths between the launch facility at Edwards Air Force Base, California, and the landing site at Michael Army Airfield at Dugway Proving Ground as part of the range test. In the first flight, the ER-2 was used to help engineers demonstrate continuous radio frequency communication between the range and the aircraft over the X-33 ground track.

The second path was used to verify range operation in case of system failures during the X-33 research flights. The ability to operate with failures present validated the redundant systems of the range.

While similar to the Air Force's U-2, the ER-2 has been adapted to carry scientific instruments in support of NASA's Earth Science Enterprise. The ER-2 has a range beyond 3,000 miles, is capable of long flight duration and can operate at altitudes above 70,000 feet. On a single flight, the ER-2 can carry more than one ton of instruments to altitudes above 65,000 feet and outside 95 percent of Earth's atmosphere, making it an excellent fill-in for the X-33. ✱

For more information, contact Gary Trippensee at Dryden Flight Research Center. ☎ 661/276-3163, ✉ [gary.trippensee@dfrc.nasa.gov](mailto:gary.trippensee@dfrc.nasa.gov) Please mention you read about it in *Innovation*.



## X-34 VEHICLE REACHES ASSEMBLY MILESTONE

**N**ASA's first X-34 has completed its transformation from a structural test vehicle into a flying experimental rocket plane and is ready to begin tests that will lead to its maiden flight. The X-34 is a flying laboratory for technologies and operations applicable to future low-cost reusable launch vehicles. It is one of a family of technology demonstrators aimed at lowering launch costs from \$10,000 to \$1,000 per pound.

NASA decided in mid-1999 to upgrade the A-1 into a flight vehicle to augment two other flying X-34s—designated A-2 and A-3—now under construction at Orbital Sciences Corporation's Dulles, Virginia facility. With this upgrade comes a new designation. The nonflying X-34 A-1 will now become the A-1A. Assembly of the second (A-2) of NASA's three X-34 rocket research planes also reached a major milestone recently with the attachment of its composite wing to its fuselage at Orbital.

Orbital is building and will operate the three experimental robot planes under contract to NASA's Marshall Space Flight Center in Huntsville, Alabama. Orbital built the A-1 as a structural test article for ground vibration and captive flights while attached to its L-1011 carrier plane. Led by Marshall, a team of engineers and technicians from Orbital, NASA's Dryden Flight Research Center in Edwards, California, and NASA's Kennedy Space Center in Florida added flight computers, electronics, hydraulics, landing gear and other equipment to the A-1A—all needed to ready this first X-34 for unpowered flights at White Sands Missile Range in New Mexico.

"The A-1A is identical to the other flight vehicles except that it lacks the thermal protection system and propulsion system required for high-speed, high-altitude flight," said Jeff Sexton, flight-testing and operations project manager for Marshall's Pathfinder Program, which includes the X-34. "But we've added all the flight mechanisms—avionics and wiring, hydraulics, control surfaces, landing gear mechanism and flight software—needed for unpowered flight testing."

The X-34's first tests, likely to have begun by press time, will not leave the ground. Instead, the vehicle will be towed behind a semi-truck for up to 10,000 feet along the desert lakebed at Edwards. Orbital plans to conduct 16 tests. The X-34 will be released at speeds up to 80 miles per hour as a way to prove the craft's guidance and navigation system, nose wheel steering, braking, rudder speed brake and rudder steering. The X-34 will be attached to the tow truck by a specially designed 500-foot rope with electrical connections to provide communications between the X-34 and ground test engineers. After successful ground testing, the A-1A will be attached to Orbital's L-1011 carrier plane, Stargazer, to finish the captive-carry flights required by the Federal Aviation Administration to verify that the combined aircraft are safe to fly.

Following those tests, the X-34 project transitions to White Sands Missile Range for unpowered flights of the A-1A. The L-1011 will carry it to an altitude of about 35,000 feet and release it to make an automated flight and landing at the White Sands Space Harbor. Five unpowered flights are planned using the A-1A. "These glide flights will give us an understanding of how the X-34 separates from the L-1011 and its flight characteristics," Sexton said. "We will be able to test its control surface effectiveness, [and] validate the flight software that controls guidance, navigation, final approach, touchdown and landing rollout without risking the two fully functional powered flight vehicles."

The suborbital X-34 is 58.3 feet (17.77 meters) long and 27.7 feet (8.44 meters) wide. It is capable of flying up to eight times the speed of sound and reaching altitudes of approximately 50 miles. It is scheduled to make a total of 27 unpowered and powered flights from government ranges in New Mexico, California and Florida.

The second vehicle, the A-2, is scheduled to make the X-34's first powered flights from Dryden at Edwards Air Force Base, California, this year. After the A-2 vehicle is assembled and tested at Orbital, the wing—manufactured by R-Cubed of West Jordan, Utah—will be removed and shipped to Dryden. The fuselage will be shipped to Holloman Air Force Base in New Mexico. There, integrated with its Fastrac rocket engine, it will undergo propulsion system testing before being shipped to Dryden, where the wing will be reattached for powered flights.

The Fastrac engine was designed and developed by Marshall, which is NASA's Lead Center for Space Transportation System Development. The first X-34 is now at Dryden being modified for unpowered flight testing at White Sands Missile Range. The third X-34, still in early stages of production, will be used to flight-test additional technologies late in the series of 27 planned X-34 missions. ✱



*This is an artist concept of the X-34 Technology Testbed Demonstrator. The X-34 will demonstrate key vehicle and operational technologies applicable to future low-cost reusable launch vehicles*

For more information, contact Seunghee Lee at Dryden Flight Research Center. ☎ 661/276-2014, ✉ [seunghee.lee@dfrc.nasa.gov](mailto:seunghee.lee@dfrc.nasa.gov) Please mention you read about it in *Innovation*.



### Increased Access to Satellite Remote-Sensing Data

**W**IDESPREAD USE OF SATELLITE DATA IN the private sector has been hampered by the high cost of ground receivers. Existing systems, such as the Alaska Synthetic Aperture Radar (SAR) Facility, which employs a 10-meter tracking antenna, cost approximately \$10 million to build.

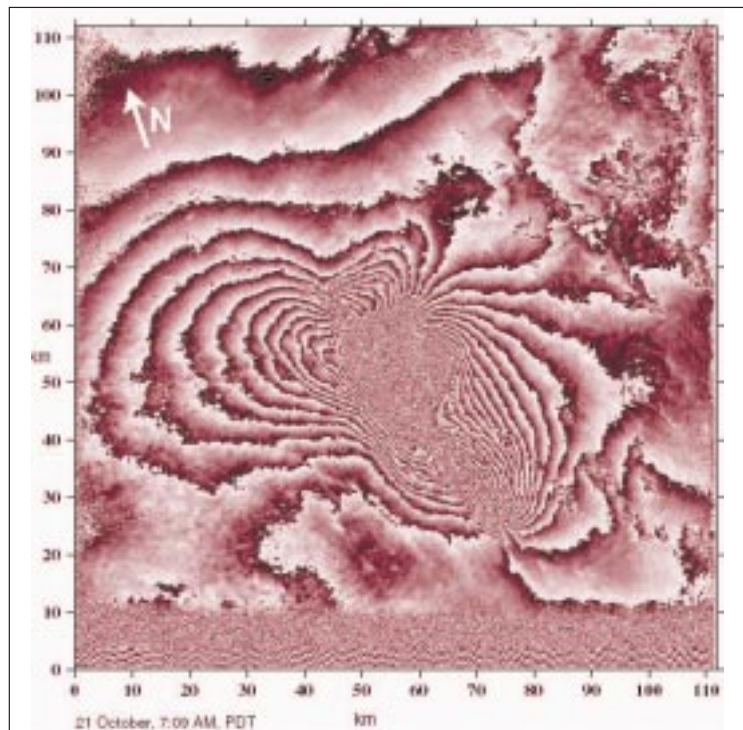
To reduce the cost of data collection and dissemination, NASA funded Seaspace Corporation to develop a low-cost receiver that would be able to capture and analyze data from Earth-observing satellites. Under an SBIR contract managed by the Jet Propulsion Laboratory in Pasadena, California, Seaspace successfully developed such a system. With a cost in the range of \$1 million, the system is capable of handling the high data rates of NASA satellite transmissions.

The initial beneficiaries of this technology development effort are the nation's colleges and universities. Direct access to a wealth of new information on atmospheric and terrestrial surface conditions will support new research on the environment and other subjects at these institutions. Also, these low-cost ground receivers or facilities will support the training of a new generation of scientists and engineers in the utilization of information collected by remote-sensing satellites.

In the coming years, NASA plans to launch several Earth-observing satellites that will provide a wealth of new observational data on Earth's surface and atmosphere.

Potential uses of these data include agriculture and forest land-use management, marine pollution studies, polar science studies and weather forecasting. Low-cost receivers will promote the commercial exploitation of this information, with corresponding benefits to the public.

Seaspace worked with the Scripps Institute of Oceanography (SIO) to develop the first working demonstration of this technology. An example of what can be done with remote-sensing data is an image they were able to prepare using the facility at SIO. The image shows the physical displacement of the land around the recent Hector earthquake in the California desert northeast of Los Angeles. The 7.1-magnitude earthquake permanently shifted the land as much as six inches near the fault line. The image was developed from a comparison of radar images taken before and after the earthquake by a European satellite, and it was prepared shortly after receiving data transmissions from the satellite.



*Using the facility at the Scripps Institute of Oceanography, scientists were able to develop an image showing the physical displacement of land around the Hector earthquake in California. (Photo supplied by Jet Propulsion Laboratory)*

SIO will be using satellite observations from this Seaspaces facility to study earthquake processes in the state of California. SIO will also use the receiver to collect data to study developments in the marine environment along the coast. ✱

For more information, contact Dr. Patricia McGuire at the Jet Propulsion Laboratory. ☎ 818/354-1258, ✉ [Patricia.A.McGuire@jpl.nasa.gov](mailto:Patricia.A.McGuire@jpl.nasa.gov) Please mention you read about it in *Innovation*.

## Removing Space Debris From LEO

**W**ORKING WITH NASA'S MARSHALL SPACE Flight Center under a Small Business Innovation Research (SBIR) agreement, Tethers Unlimited, Inc. is currently developing a system called the Terminator Tether™, which will provide a low-cost, lightweight and reliable method of removing objects from low-Earth orbit (LEO).

Space debris is becoming a problem. Increased amounts of space debris, traveling at orbital speeds

(7 to 8 kilometers per second), pose a significant threat to the Space Shuttle, the International Space Station and the many satellites in Earth orbit. The number of satellites (more than 8,000), countless smaller pieces of debris generated by spacecraft explosions and collisions between satellites, and other large objects orbiting Earth has grown quickly.

Until recently, it has been standard practice to put a satellite into orbit and leave it there. To prevent old satellites, spent rockets and the orbital debris they generate from making LEO unusable, satellite users must begin to provide a means of removing their old satellites and spent rockets from orbit.

A number of telecommunications firms have plans to deploy satellite constellations in LEO and mid-Earth orbit that will have tens to hundreds of satellites each. These satellites will have operational lifetimes of 5 to 10 years, and thus the constellations will require the constant replacement of old satellites. Satellites and other objects placed in LEO will remain in orbit for many years. How long depends on their perigee altitude, but objects in orbits above approximately 700 kilometers will stay in orbit for hundreds or even thousands of years.

### INNOVATIVE SMALL BUSINESS PROJECTS SELECTED

**N**ASA has selected 25 research proposals for negotiation of Phase II contract awards under its Small Business Innovation Research (SBIR) program, which is designed to stimulate small and disadvantaged businesses to develop new technologies. The 25 awards are to be conducted by firms in 12 states. These selections will assist future NASA missions by providing advanced technologies in such areas as high-optical-quality and lightweight reflectors and mirrors, high-speed digital communications links with reduced power and size requirements and reduced mass requirements for spacecraft thermal-control systems.

Phase II continues the development of the most promising previously selected Phase I projects. Selection criteria include scientific and technical merit, future importance and eventual value of the innovation to NASA, company capabilities and commercial potential. Funding for Phase II contracts may be up to \$600,000 for a two-year performance period. SBIR contractors submitted 319 Phase II proposals; 103 of these proposals were selected in late August 1999. Based on current budget availability, these additional 25 selections have been announced.

The goals of the SBIR program are to stimulate technological innovation, increase the use of small business (including women-owned and disadvantaged firms) in meeting federal research and development needs and increase private-sector commercialization of federally funded research results. Four of the companies selected are disadvantaged firms, and three are women-owned firms.

The NASA SBIR Program Management Office is located at its Goddard Space Flight Center in Greenbelt, Maryland, with executive oversight by NASA's Office of Aerospace Technology at NASA Headquarters in Washington, DC. Individual SBIR projects are managed by NASA's 10 field centers. ✱

For more information, visit <http://sbir.nasa.gov>

Findings from recent studies have proven that LEO is not a limitless resource and must be managed carefully in the future. The studies of interactions of satellite constellations with the space debris environment have concluded that, without debris mitigation measures, the debris environment cannot sustain the long-term operation of large constellations but could sustain the long-term operation of medium-sized constellations of up to 100 satellites at high collision risk. Or, larger constellations of up to 350 satellites could be deployed in lower collision risk orbits as long as strict mitigation measures are implemented, such as explosion prevention and immediate satellite deorbiting upon end-of-life and failure.

Currently, there is no law requiring that old satellites be removed from orbit. However, NASA has recently implemented a guideline for its own satellites, and it is likely that this guideline, or one like it, will become a law.

Satellites typically have some means of propulsion for orbit corrections. One method of removing a satellite from orbit would be to carry extra propellant so that the satellite can bring itself down out of orbit. However, this method requires a large mass of propellant, and every kilogram of propellant that must be carried up reduces the weight available for revenue-producing transponders. Moreover, this requires that the rocket and satellite guidance systems must be functional after sitting in orbit for 10 years or more. Often, this is not the case, and the satellite ends up stuck in its operational orbit.

Some organizations are currently planning on boosting their satellites to higher, “graveyard” orbits at the end of their missions. This also requires that the satellite’s power, propulsion and guidance be working at the end of the satellite’s mission. However, this does not really solve the problem—it just delays it, somewhat like a toxic waste dump.

The results of recent studies have indicated that satellites left in a higher graveyard orbit will slowly

break apart as micrometeorites hit them, and the smaller fragments will filter back down to lower altitudes. Thus satellites boosted to higher disposal orbits could eventually endanger operational satellites and manned operations in LEO. Also, once the old satellites fragment into smaller particles, it will be nearly impossible to clean up the debris. Consequently, it will be much more cost effective in the

long run to address the problem properly from the start and deorbit all spacecraft as soon as they complete their operational missions.

The Terminator Tether device will provide a lower mass and more reliable means of bringing old satellites out of orbit. The device will be a small package bolted onto the satellite. When the end of the satellite’s useful life is reached, the Terminator Tether will deploy a sev-

eral-kilometer length of conducting tether from the satellite. Because the satellite and tether are moving at great speed across Earth’s magnetic field, a voltage will be induced along the tether. This voltage will cause a current to flow along the tether. At the ends of the tether, the current will be transmitted to the thin space plasma present in LEO.

The current flowing through the tether will cause power to be dissipated in the resistance of the metal in the tether. This power has to come from somewhere, and it comes out of the orbital energy of the satellite. As a result, the orbit of the satellite decays, and this decay can be very rapid. Calculations indicate that a tether with a mass of as little as two percent of the satellite mass can bring a satellite out of some orbits in just a few weeks (compared to centuries without the Terminator Tether). As an example of the potential mass savings, to deorbit a two-metric-ton satellite from a 1,000-kilometer orbit using chemical rockets would require approximately 200 kilograms of propellant. The Terminator Tether could do the same job, but it would require only 25 kilograms of propellant.

Under NASA SBIR Phase I funding with Marshall, Tethers Unlimited has developed a numerical simula-

CURRENTLY, THERE IS NO LAW  
REQUIRING THAT OLD SATELLITES  
BE REMOVED FROM ORBIT.  
HOWEVER, NASA HAS RECENTLY  
IMPLEMENTED A GUIDELINE FOR  
ITS OWN SATELLITES, AND IT IS LIKELY  
THAT THIS GUIDELINE, OR ONE LIKE IT,  
WILL BECOME A LAW.

tion of electrodynamic tethers, which includes models for all of the orbital dynamics, tether dynamics, plasma physics and other physical phenomena relevant to the Terminator Tether. Using this simulation, Tethers Unlimited has studied the performance of the Terminator Tether for disposing of LEO constellation satellites and upper stages.

In April 1999, Tethers Unlimited signed a two-year SBIR Phase II contract to continue developing the patent-pending deorbit device. The company hopes to have a prototype Terminator Tether ready soon to demonstrate in a test flight. ✱

For more information, visit [www.tethers.com](http://www.tethers.com)

## Laser Technology Finds Wide Commercial Application

**L**ASER TECHNOLOGY DEVELOPED BY SDL INC. for use in space communications systems has been incorporated into several successful commercial products. The laser products are based on a Small Business Innovation Research (SBIR) technology development effort managed by the Jet Propulsion Laboratory in Pasadena, California, a division of the California Institute of Technology.

Commercial products include lasers for marking industrial materials, precision cutting and welding, high-resolution soldering, thin film etching and research and development work. High output power, precise control and compact design are some of the features of this technology that make it attractive for these as well as future space communications applications.

SDL lasers are capable of projecting circular spots of light as small as a few microns (one micron equals one millionth of a meter) in size. The intensity of the light provides near instantaneous etching of surfaces to precisely controlled depths (plus or minus two microns) for marking items such as semiconductor chips. Moving rapidly along the surface, the laser quickly marks the semiconductor chips with product identification. This same precise beam of light can be used to achieve precise heating for soldering or welding, or

at greater intensity to cut through materials.

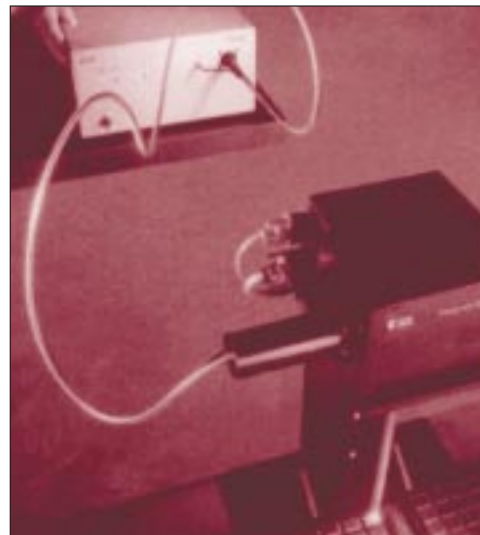
The high-power output begins with laser light from a laser diode. Laser diodes are capable of producing a ray of laser light at a precise wavelength and are able to modulate the amplitude of the light at very high frequencies. The next step is to amplify this signal or beam of laser light without distortion. This is accomplished in a special optical fiber that is capable of lasing at the same wavelength. When the laser light from the laser diode enters the optical fiber, a lasing process is initiated that greatly amplifies the original signal.

A separate high-power pump laser provides energy for this lasing process. Operating at a different light frequency, the pump laser energizes the optical fiber without interfering with the lasing process.

NASA's interest in developing communications systems using lasers is based on the promise of higher efficiency in comparison with conventional systems. Unlike radio frequency transmissions, laser signals can be focused in a tight narrow beam, minimizing the amount of energy required to transmit the signal. Information collected by scientific instruments can be encoded in this beam of light through rapid modulation in the signal's intensity. This is similar to the process used to transmit phone calls over optical fibers. The major difference is that the transmitter and receiver are no longer connected by an optical glass fiber.

Recent advances in laser technology by SDL and others have made the technology attractive for NASA applications on the International Space Station, the Next Generation Space Telescope and other near-Earth missions. Similar systems may soon link communications satellites, helping provide cellular phone services around the world. ✱

For more information, contact Byron L. Jackson at the Jet Propulsion Laboratory. ☎ 818/354-1246, ✉ [Byron.L.Jackson@jpl.nasa.gov](mailto:Byron.L.Jackson@jpl.nasa.gov) Please mention you read about it in *Innovation*.



*Laser technology developed by SDL, Inc. for use in space communications systems has been incorporated into several successful commercial products. (Photo supplied by Jet Propulsion Laboratory)*



# TECHNOLOGY OPPORTUNITY SHOWCASE

Moving Forward



**Technology Opportunity Showcase** highlights some unique technologies that NASA has developed and which we believe have strong potential for commercial application. While the descriptions provided here are brief, they should provide enough information to communicate the potential applications of the technology. For more detailed information, contact the person listed. Please mention that you read about it in *Innovation*.

## Distributed Sensor System (DSS)—Continuous Monitoring of Strain

Langley Research Center is seeking qualified companies to license a new distributed sensor system that is superior to conventional strain sensors for monitoring large and/or complex load-bearing structures. It increases the ability of researchers to determine structural integrity in a cost-effective manner by embedding the fiber sensor in load-bearing structures, such as aerospace vehicles, bridges, dams, oil wells and industrial machinery. Also, an internal, highly automated inspection technique can potentially eliminate the need for costly manual inspection. The Distributed Strain Sensor (DSS) is used to determine the Fiber Bragg Gratings' (FBGs) reflectivity and wavelength at every point along an optical fiber. These data are obtained by measuring the interference of the light reflected from the FBGs with the light reflected from a reference reflector. The reflected spectrum of any section of fiber can then be computed. Shifts in this spectrum then provide an accurate measurement of the strain in that fiber section. Currently, sections can be as short as 1.5 inches and range over 20 feet. A plot of the FBGs gratings along the length of the sensing fiber can be generated to show the location, length and relative strength of all the FBGs. Because the reference reflector is located in the same fiber with the FBGs, very long lead lengths, possibly miles, can exist between the demodulation instrumentation and the sensing fiber. The DSS has been used to successfully demodulate 200 FBGs in a two-meter section of optical fiber. Researchers at Langley plan to use this technology to demodulate up to 800 FBGs over an eight-meter fiber for strain measurements. FBGs are demodulated based on their distance from the reference reflector, allowing all of the gratings to be written at the same wavelength and thereby dramatically simplifying the manufacturing of the sensing fiber. ✱

For more information, contact Sherry Sullivan at Langley Research Center.  
☎ 757/864-2556, ✉ [s.l.sullivan@larc.nasa.gov](mailto:s.l.sullivan@larc.nasa.gov) Please mention you read about it in *Innovation*.

## Fiber Dispersion Measurement System

Langley Research Center is looking for licensees for its fiber dispersion measurement system, which analyzes a variety of wave devices, such as Fiber Bragg Gratings (FBGs), directional couplers, isolators, connectors, amplitude modulators, amplifiers and wave division multiplexers. These devices are playing an increasingly important role in the world's telecommunications network; therefore, it is important to understand how they

will affect signal transmissions. Current testing technology is both expensive and time consuming. NASA has developed a new system for faster and less costly analysis of these devices. With current technology, a tunable laser is modulated by a fixed frequency oscillator in the gigahertz range. The modulated light experiences a delay as a result of propagating down the fiber and reflecting off of the grating. The light is detected by a high-speed detector, and the modulation signal is recovered. The phase shift caused by the fiber propagation is then detected. NASA's Fiber Dispersion Measurement System (FDMS) allows many of the expensive components of current systems to be eliminated—expensive high-bandwidth electronics, vector volt meters, high-frequency oscillators and high-speed electro-optic modulators. Instead, FDMS relies on interference phenomena to measure grating transmission properties. NASA has built a simple version of the system, which has yielded excellent results. The innovation can fully characterize any fiber device's phase, amplitude, transmission and reflection from either direction in 30 seconds. Current technology requires approximately 20 minutes per grating. The system may be manufactured for as little as \$50,000, approximately one-third of the cost of current technology. ✱

For more information, contact Sherry Sullivan at Langley Research Center.  
☎ 757/864-2556, ✉ [s.l.sullivan@larc.nasa.gov](mailto:s.l.sullivan@larc.nasa.gov) Please mention you read about it in *Innovation*.

## Process for Waterproofing of Low-Density Aerogels

Ames Research Center is seeking commercial partners to license technology for waterproofing low-density aerogels after they have been produced and dried. Waterproofing prevents aerogel collapse due to water absorption and prevents moisture uptake. This waterproofing process is long lasting; it allows aerogels waterproofed by this method to stay waterproofed even after floating in water for a week. The process is inexpensive, simple, long-lasting, versatile, repeatable and extremely effective. This technology can be used to waterproof all types of low-density aerogels and xerogels, which in turn have many applications, including window and skylight insulation, automotive catalytic converters, air filtration, aerospace insulation, refrigerator and oven insulation, cryogenic storage insulation, electrolytic capacitors, electronic insulators and furnace insulation. ✱

For more information, contact Phil Herlth, Technology Commercialization Manager at Ames Research Center. ☎ 650/604-0625, ✉ [pherlth@mail.arc.nasa.gov](mailto:pherlth@mail.arc.nasa.gov) Please mention you read about it in *Innovation*.

# Moving Forward NCTN DIRECTORY



## NASA Field Centers

### Ames Research Center

Selected technological strengths are Information Technologies, Aerospace Systems, Autonomous Systems for Space Flight, Computational Fluid Dynamics and Aviation Operations.

#### Carolina Blake

Ames Research Center  
Moffett Field, California 94035-1000  
650/604-1754  
cblake@mail.arc.nasa.gov

### Dryden Flight Research Center

Selected technological strengths are Aerodynamics, Aeronautics Flight Testing, Aeropropulsion, Flight Systems, Thermal Testing and Integrated Systems Test and Validation.

#### Jenny Baer-Riedhart

Dryden Flight Research Center  
Edwards, California 93523-0273  
661/276-3689  
jenny.baer-riedhart@mail.dfrc.nasa.gov

### Glenn Research Center

Selected technological strengths are Aeropropulsion, Communications, Energy Technology and High Temperature Materials Research, Microgravity Science and Technology and Instrumentation Control Systems.

#### Larry Viterna

Glenn Research Center  
Cleveland, Ohio 44135  
216/433-3484  
Larry.A.Viterna@grc.nasa.gov

### Goddard Space Flight Center

Selected technological strengths are Earth and Planetary Science Missions, LIDAR, Cryogenic Systems, Tracking, Telemetry, Command, Optics and Sensors/Detectors.

#### George Alcorn

Goddard Space Flight Center  
Greenbelt, Maryland 20771  
301/286-5810  
george.e.alcorn.1@gsfc.nasa.gov

### Jet Propulsion Laboratory

Selected technological strengths are Deep and Near Space Mission Engineering and Operations, Microspacecraft, Space Communications, Remote and In-Situ Sensing, Microdevices, Robotics, and Autonomous Systems.

#### Merle McKenzie

Jet Propulsion Laboratory  
Pasadena, California 91109  
818/354-2577  
merle.mckenzie@jpl.nasa.gov

### Johnson Space Center

Selected technological strengths are Life Sciences/Biomedical, Spacecraft Systems, Information Systems, Robotic and Human Space Flight Operations.

#### Henry (Hank) Davis

Johnson Space Center  
Houston, Texas 77058  
281/483-0474  
henry.l.davis@jsc.nasa.gov

### Kennedy Space Center

Selected technological strengths are Emissions and Contamination Monitoring, Sensors, Corrosion Protection and Biosciences.

#### Gale Allen

Kennedy Space Center  
Kennedy Space Center,  
Florida 32899  
407/867-6226  
gale.allen-1@kmail.ksc.nasa.gov

### Langley Research Center

Selected technological strengths are Aerodynamics, Flight Systems, Materials, Structures, Sensors, Measurements and Information Sciences.

#### Sam Morello

Langley Research Center  
Hampton, Virginia 23681-0001  
757/864-6005  
s.a.morello@larc.nasa.gov

### Marshall Space Flight Center

Selected technological strengths are Materials, Manufacturing, Non-destructive Evaluation, Biotechnology, Space Propulsion, Controls and Dynamics, Structures and Microgravity Processing.

#### Sally Little

Marshall Space Flight Center  
Huntsville, Alabama 35812  
256/544-4266  
sally.little@msfc.nasa.gov

### Stennis Space Center

Selected technological strengths are Propulsion Systems, Test/Monitoring, Remote Sensing and Nonintrusive Instrumentation.

#### Kirk Sharp

Stennis Space Center  
Stennis Space Center, Mississippi  
39529-6000  
228/688-1914  
kirk.sharp@ssc.nasa.gov

## NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Joseph C. Boeddeker  
**Ames Technology Commercialization Center**  
San Jose, CA  
408/557-6789

Greg Hinkebein  
**Mississippi Enterprise for Technology**  
Stennis Space Center, MS  
228/688-3144

Wayne P. Zeman  
**Lewis Incubator for Technology**  
Cleveland, OH  
216/586-3888, 216/229-9445

Thomas G. Rainey  
**Florida/NASA Business Incubation Center**  
Titusville, FL  
407/383-5200

Celeste Moore  
**University of Houston/NASA Technology Center**  
Houston, TX  
713/743-0451

Joanne Randolph  
**Business Technology Development Center**  
Huntsville, AL  
256/704-6000, ext. 202

Richard C. (Michael) Lewin  
**Department of Business and Economic Development**  
Greenbelt, MD  
800/541-8549

Julie A. Holland  
**NASA Commercialization Center/California State Polytechnic University**  
Pomona, CA  
909/869-4477

Martin Kaszubowski  
**Hampton Roads Technology Incubator**  
Hampton, VA  
757/865-2140

## Small Business Programs

Carl Ray  
NASA Headquarters  
**Small Business Innovation Research Program (SBIR/STTR)**  
202/358-4652  
cray@hq.nasa.gov

Paul Mexcur  
Goddard Space Flight Center  
**Small Business Technology Transfer (SBIR/STTR)**  
301/286-8888  
paul.mexcur@pop700.gsfc.nasa.gov

## NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D agencies and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the RTTC nearest you, call 800/642-2872.

Ken Dozier  
**Far West Technology Transfer Center**  
University of Southern California  
213/743-2353

Dr. William Gasko  
**Center for Technology Commercialization**  
508/870-0042

J. Ronald Thornton  
**Southern Technology Applications Center**  
University of Florida  
352/294-7822

Gary F. Sera  
**Mid-Continent Technology Transfer Center**  
Texas A&M University  
409/845-8762

Lani S. Hummel  
**Mid-Atlantic Technology Applications Center**  
University of Pittsburgh  
412/383-2500

Christopher Coburn  
**Great Lakes Industrial Technology Center**  
Battelle Memorial Institute  
440/734-0094

Joseph P. Allen  
**National Technology Transfer Center**  
Wheeling Jesuit University  
800/678-6882

Doris Rouse  
**Research Triangle Institute Technology Applications Team**  
Research Triangle Park, NC  
919/541-6880

## NASA ONLINE

Go to the **NASA Commercial Technology Network (NCTN)** on the World Wide Web at <http://nctn.hq.nasa.gov> to search NASA technology resources, find commercialization opportunities and learn about NASA's national network of programs, organizations and services dedicated to technology transfer and commercialization.

## MOVING FORWARD

## Events

NASA will be a participating sponsor in the Technology 2000 annual event occurring from October 31-November 2, 2000 in Seattle, WA. This year's event will collocate three synergistic shows, which include the eleventh annual **Technology 2000 National Technology Expo and Conference**, showcasing new and next-generation technologies; the third annual **Small Business Tech Expo**, showcasing the latest resources and technology-driven product development firms available for successful partnering opportunities; and the **National SBIR Conference**, with 11 federal agencies in attendance and access to the nation's largest source of early stage technology funds. General update information on the show can be followed online at <http://www.t2kexpo.com/>. For more information regarding the event or registering for discounted booth space, please call the show producers, DelaBarre & Associates, Inc. at 360/683-1828; Fax 360/683-6654; or send an e-mail to [del@zyn.com](mailto:del@zyn.com)

Join more than 25,000 professionals who will boost their careers at **ISA EXPO/2000**, August 21 through 24, 2000 in New Orleans. ISA EXPO/2000 offers four days of technical conferences, half-day and one-day seminars discussing new technology topics and training courses on topics including fieldbus, sensors and PLCs. Industry experts will speak at topical luncheon seminars and forums, while the Sensors Pavilion will provide information about the latest sensors technology from lead-

ing manufacturers. In addition, the Integrated Manufacturing Solutions (IMS) EXPO will be held concurrently with ISA EXPO/2000. Registration for either conference provides admission to the other conference. IMS EXPO exhibits will feature almost 750 of the industry's leading manufacturers and suppliers demonstrating the latest technologies and equipment. For more information about ISA EXPO/2000, visit [www.isamarketplace.org](http://www.isamarketplace.org). For more information about IMS EXPO, visit <http://www.isa.org/imsexpo/>

## Announcements

Projects Unlimited, Inc. in Dayton, Ohio has **signed a Memorandum of Understanding (MOU) with NASA Langley Research Center, Hampton, Virginia, to develop a vibrational/acoustical personal communication device**. The three-way communication device will be capable of vibration, audio alert and sound. Under the MOU, Langley will build a prototype device to demonstrate the performance enhancements to be gained by applying NASA Langley's ModalMax technologies to existing personal communication devices. Projects Unlimited will provide system requirements, oversee prototype development and assess the commercial viability of the device in the pager and cellular phone markets. For more information, contact Cheryl Allen, Technology Commercialization Project Manager at Langley Research Center, 757/864-4438 or [C.L.Allen@larc.nasa.gov](mailto:C.L.Allen@larc.nasa.gov) ✱



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